

## **TORQUE-LIMITING LOCKNUT**

### **BACKGROUND OF THE INVENTION**

#### **Field of the Invention**

This invention relates generally to fasteners and, more specifically to locknuts  
5 adapted for use with threaded shafts, such as bolts.

#### **Discussion of the Related Art**

Nuts are commonly provided with an inner thread that is adapted to engage an outer  
thread on a shaft. Rotation of the nut relative to the shaft moves the nut axially along the  
shaft. The threads of the nut can be tightened on the threads of the shaft by applying a  
10 torque, the magnitude of which depends on the resistance to rotational and axial  
movement. This torque places stress on the inner threads of the nut, the outer threads of  
the shaft, the shaft itself, and any object resisting axial movement of the nut relative to the  
shaft. Any one of these elements of structure can fail when the torque exceeds a particular  
value. Accordingly, it is often desirable to limit the torque that can be applied to the nut in  
15 order to inhibit failure of these various structural elements. One element that is commonly  
overstressed is the shaft, particularly when it is provided with a tubular configuration.  
Under these circumstances, the walls of the shaft are particularly susceptible to breaking  
under high torque conditions. The structure of the shaft is even further susceptible to  
breakage when the shaft is made of a non-metal material such as plastic.

20 In the past, torque-limiting nuts have been provided but typically with very complex  
structures involving many parts, and a tedious manufacturing process. These nuts have  
also commonly been made of metal, which does not benefit from the injection molding  
techniques available to plastic materials. The nuts have also been provided with designs  
that tend to fail at the torque limit rendering them subsequently useless. In some cases,  
25 the nuts have desirably provided a limiting torque in the forward direction, but have

undesirably also provided that limiting torque in a reverse direction. Often this has made it impossible to remove the nut.

## SUMMARY OF THE INVENTION

5 In accordance with the present invention, a locknut is provided with characteristics that make it impossible to tighten the nut beyond a predetermined torque. As a result, fragile objects such as a thin or plastic shaft, outer threads of the shaft, inner threads of the nut, and objects limiting axial travel of the nut, can be protected from damage due to over-torquing of the nut. In various embodiments of the torque limiting nut, a wall is provided  
10 that is radially deflectable in response to a torque greater than a predetermined torque, to disengage the outer threads of the nut in response to an elevated torque.

In one aspect, the nut is adapted for axial engagement of a threaded shaft having an axis and an outer thread, the nut having properties for limiting a tightening torque on the shaft to a predetermined value. A first member is adapted for rotation about the threaded  
15 shaft to facilitate engagement and advancement of the nut along the outer threads. At least one deflection wall is provided in the first member with a generally cylindrical configuration. A second member engages the first member in a coaxial relationship and has an inner thread that is adapted to engage the outer thread of the shaft. At least one deflecting element is included in the second member and disposed in an engaging relationship with  
20 the deflection wall. This deflecting element has a generally fixed relationship with the deflection wall at a torque level less than the predetermined torque, to maintain the inner threads of the second member in an engaged relationship with the first member. The deflecting element has a generally free-moving relationship with the deflection wall at a torque level greater than the predetermined torque to maintain the inner threads of the  
25 second member in a generally disengaged relationship with the first member.

In another aspect of the invention, the second member has a coaxial relationship with the first member. In this case, the second member and the first member have a

rotatable relationship with respect to each other, which is dependent upon an applied torque force. This torque force is in turn dependent on an interference fit between the first member and the second member. This interference fit increases as the torque force approaches a predetermined torque level and decreases beyond the predetermined torque level.

In a further aspect of the invention, the torque-limiting nut has an outer wall that is sized and configured for engagement by the user and adapted for application of the tightening torque to advance the nut on the threaded shaft. An inner wall can be made integral with the outer wall and disposed radially inwardly of the outer wall. Portions of the inner wall define an inner screw thread sized and configured to engage the outer screw thread of the shaft. These portions of the inner wall have a first position wherein the inner threads engage the outer threads to facilitate tightening the nut on the shaft and a second position wherein the inner thread disengages the outer thread at the predetermined torque to inhibit any further tightening of the nut on the shaft.

These and other features and advantages of the invention will become more apparent with a description of preferred embodiments and reference to the associated drawings.

### DESCRIPTION OF THE DRAWINGS

Figure 1 is a front elevation view of a toilet, partially in phantom and illustrating a fill valve having a threaded shaft and the torque limiting nut of the present invention;

Figure 2 is a top plan view of a first member of the torque-limiting nut having an outer wall for the application of torque and an inner deflection wall;

Figure 3 is a bottom plan view of the first member showing in greater detail the outer wall and the deflection wall;

Figure 4 is a top plan view of a second member of the torque-limiting nut showing a plurality of deflecting elements;

Figure 5 is a bottom plan view of the second member illustrated in Figure 4;

Figure 6 is a cross section view taken along lines 6-6 of Figure 3;

5        Figure 7 is a cross section view taken along lines 7-7 of Figure 4;

Figure 8 is a cross section view illustrating the first member of Figure 6 in a rotational, snap-fit relationship with the second element of Figure 7;

Figure 9 is a top plan view of the deflection wall relative to the deflecting element in a first quadrant of operation;

10       Figure 10 is a top plan view showing the deflection wall and the deflecting element in a second quadrant of operation;

Figure 11 is a top plan view showing the deflection wall and the deflecting element in a third quadrant of operation;

15       Figure 12 is a top plan view showing the deflection wall and the deflecting element in a fourth quadrant of operation;

Figure 13 is a graph showing applied torque plotted against the four quadrants illustrated in Figure 9 through Figure 12;

Figure 14 is bottom plan view of a further embodiment of the invention including deflecting walls that are threaded;

20       Figure 15 is a cross section view taken along lines 14-14 of Figure 13; and

Figure 16 is a cross section view similar to Figure 14 and illustrating deflection of the deflection walls in response to a torque greater than the predetermined torque.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS AND BEST MODE OF THE INVENTION

A torque-limiting nut of the present invention is illustrated in Figure 1 and designated with the reference numeral 10. The nut 10 is operatively disposed on a shaft 12 having  
5 outer threads 14. The shaft 12 in this case forms the input tube of a fill valve 16 associated with a tank 18 of a toilet 21. Water, available through a valve 23 at a wall 25, is conducted through a flexible pipe 27, which in turn is coupled to the shaft 12 and metered by the valve 16 into the tank 18.

In this case, the amount of torque applied to the nut 10 produces an increasing force  
10 on the shaft 12, threads 14, as well as the nut 10. Since the shaft 12 is typically made of plastic, and since it has a tubular configuration, the thin walls associated with the tube 12 are particularly susceptible to damage due to over-tightening of the nut 10. In order to limit the risks of breaking the shaft 12 or deforming the threads 14, the nut 10 in this case is provided with characteristics that limit the tightening torque, and consequently the force is  
15 applied to the shaft 12 and threads 14.

In a preferred embodiment, the nut 10 can be formed as a combination of two members 27 and 30. The first member 27 is illustrated in the top plan view of Figure 2 and the bottom plan view of Figure 4. The second member 30 is illustrated in the top plan view of Figure 3 and the bottom plan view of Figure 5.

In Figure 2, the first member 27 is shown with an outer wall 32, which can be configured for the application of torque, using a wrench (not shown), or fingers engaging a pair of opposing ears 34 and 36. An inner wall 38, best illustrated in Figure 3, can be formed with a cylindrical configuration and can be divided into any number of deflection walls 38, 41, 43, and 45, four being shown in the embodiment of Figure 3. The deflection  
20 walls 38-45 in the illustrated embodiment are formed of a material common to that of the outer wall 32 and joined to the outer wall 32 by a base 47 having a top surface 50 (Figure 2). Each of the deflection walls 38-45 has a leading edge (in the direction of the  
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tightening torque) and a trailing edge. For example, the deflection wall 45 has a leading edge 52 and a trailing edge 54, and the deflection 43 has a leading edge 56 and a trailing edge 58.

Between adjacent deflection walls 38-45, an opening can be formed. For example,  
5 between the deflection walls 43 and 45, an opening 61 can be defined by the leading edge 52 of the deflection wall 45 and the trailing edge 58 of the deflection wall 43. This opening 61 is perhaps best illustrated in the cross section view of Figure 6.

The second member 30 of this embodiment of the torque-limiting nut 10 is illustrated in the top plan view of Figure 4 and the bottom plan view of Figure 5. This second  
10 member 30 includes a base 70 having a bottom surface 72 best shown in Figure 7. The second member 30 also has an upstanding cylindrical wall 74 that extends upwardly from the base 70 and terminates in a plurality of snap hooks 76, four of which are illustrated in Figure 4. Interiorly of the cylindrical wall 74, an inner thread 78 is sized and configured to receive the outer thread 14 on the shaft 12 (Figure 1). Of particular interest to this  
15 embodiment is a plurality of deflecting elements 81, 83, 85 and 87, which are preferably equal in number to the number of deflection walls 38-45.

With the first member 27 and second member 30 thus configured, they are specifically adapted to be aligned and coupled in a snap-fit relationship. As illustrated in Figures 6 and 7, these two members 27 and 30 can be axially moved together as illustrated  
20 by arrows 90 and 92 in Figure 6. During this assembly, the snap hooks 76 deflect slightly radially inwardly along the deflection walls 38-45 until the hooks 76 clear the top surface 50 of the base 47. At this point, the hooks 76 snap over the top surface 50 thereby maintaining the first member 27 and the second member 30 in a rotatable but axially engaged relationship. It is intended that these two members 27 and 30 not be separated  
25 from their snap-fit relationship, as illustrated in Figure 7, but remain joined throughout the use of the nut 10.

The torque-limiting characteristics associated with the nut 10 are derived in this embodiment from the interaction of the deflection walls 38-45 and the associated deflecting elements 81-85. By way of illustration, the deflection wall 45 is illustrated with the deflecting element 83 in the radial cross section view of Figure 9. In this figure, the deflection wall 45 is shown with its leading edge 52 and its trailing edge 54 defined with respect to a tightening torque directed along an arrow 94. This deflection wall 45 is further defined by four quadrants 94, 96, 98, and 101, each of which functions in a different manner with respect to the deflecting element 83.

The first quadrant 94 is characterized primarily by the width of the opening 61 (Figure 3) between the deflection wall 45 and the deflection wall 43.

The second quadrant 96 is disposed at the leading edge 52 of the deflection wall 45, which has a length of reduced thickness, shown by the dimension 105, which is reduced compared to an enlarged thickness shown by the dimension 107.

The second quadrant 96 is defined by a radius 114 that leads to the length of reduced thickness 105 and an incline 110 that ramps outwardly to the greater thickness 107.

The third quadrant 98 is defined primarily by the greater thickness 107. It begins with the incline 110, which ramps outwardly from the lesser thickness 105 to the greater thickness 107. The third quadrant 98 ends at an abrupt shoulder 112, which partially defines the opening between the deflection wall 45 and the deflection wall 38 (Figure 3). This opening is characterized as the fourth quadrant 101.

In Figure 9, it can also be seen that the deflecting element 83 in this embodiment is characterized by an abrupt shoulder 116 at the trailing end of the element 83, and an incline 118 facing the leading end 52 of the deflection wall 45.

As the deflecting element 83 moves relative to the deflection wall 45 through the quadrants 94-101, an interference fit is exhibited between an inner surface 121 on the

deflection wall 45 and an outer surface 123 on the deflecting element 83. In a preferred embodiment, the surfaces 121 and 123 are roughened in order to increase the coefficient of friction between these two surfaces.

5 Torque is initially applied by the user to the outer wall 32 of the first member 27 (Figure 2). In response to that torque, the deflection wall 45 moves in the direction of the arrow 103 in Figure 9. At low magnitudes of torque, the leading edge 52 of the deflection wall 45 merely pushes the deflecting element 83 ahead of it to rotate the cylindrical wall 74 and associated threads 78 of the second member 30.

10 As the threads 78 of the second member 30 tighten on the outer threads 14 of the shaft 12 (Figure 1), the resistance to turning increases and eventually the radius 114 of the deflection wall 45 rides up on the incline 118 of the deflecting element 83. This causes the length of lesser thickness 105 to deflect radially outwardly in the second quadrant 96.

15 As illustrated in the graph of Figure 13, the torque rises only slightly in the quadrant 94 and then ramps up rapidly as the area of lesser thickness 105 is deflected. Once the inner surface 121 and outer surface 123 are fully engaged as illustrated in Figure 10, the torque ramps at a lesser degree but continues to build as illustrated by the line 132 in Figure 13.

20 As the deflecting element 83 moves into the third quadrant 98, the greater thickness 107 provides an increased resistance to deflection and the torque further builds along a line 134 in Figure 13. This resistance to deflection and the corresponding tightening torque builds as the deflecting element 83 approaches the shoulder 112 at the trailing end 54 of the deflection wall 45. At this point, illustrated in Figure 12, the shoulder 116 of the deflecting element 83 clears the shoulder 112 of the deflection wall 45 and the corresponding torque snaps to zero as illustrated by a line 136 in Figure 13.

25 It can be appreciated that this movement of the deflecting element 83 through the quadrants 94-101 is repeated as the deflecting element 83 moves on to contact the leading



edge of the next deflection element 38 (Figure 4). Further movement of the first member 27 relative to the second member 30 will merely reproduce the torque curve of Figure 13. Note that at no time will the torque applied by the nut 10 to the shaft 12 (Figure 1) be greater than at a point 136 illustrated at the end of the third quadrant 98 in Figure 13. The magnitude of the tightening torque at this point 136 can be adjusted during the manufacturing process by controlling the greater thickness 107 of the deflection wall 45, and the roughness of the surfaces 121 and 123, for example.

With further reference to Figure 12, it can be seen that the nut 110 can be easily unscrewed by applying a reverse torque, for example in the direction of an arrow 141. This movement will bring the abrupt shoulder 112 of the deflection wall 45 into engagement with the abrupt shoulder 116 of the deflecting element 83. With this configuration, the wall 45 will not deflect but will maintain full engagement between the first member 27 and second member 30. It is of particular advantage to this construction that torques greater than the predetermined torque can be applied if necessary to remove the nut 10 from the shaft 12.

A further embodiment of the nut 10 is illustrated in Figures 12-14 wherein elements of structure similar to those previously discussed are illustrated with the same reference numeral followed by the lower case letter "a." Thus, in Figure 12, the nut 10a is illustrated with an outer wall 32a that can be turned or torqued, for example, by engaging the ears 34a and 36a.

In this single piece construction, the deflection walls 38a-45a are threaded along their inner surfaces to form the inner thread 78a. This thread 78a is discontinuous where the adjacent deflection walls 38a-45a define openings, such as the opening 61a.

Operation of this single piece nut 10a is illustrated in Figure 14, which also shows the tubular shaft 12a and associated outer threads 14a. In this view, the nut 10a has been tightened to the predetermined torque level, causing the inner threads 78a to move axially along the outer threads 14a. This movement causes the deflection walls 38a-45a to bend outwardly until the inner threads 78a clear the outer threads 14a. At this point, the nut 10a

moves axially one thread width thereby reducing the tightening torque of the nut. It can be seen that continued attempts to tighten the nut 10a will each terminate at the predetermined torque where the nut 10a jumps axially backwardly relative to the shaft 12a as illustrated by arrows 143.

5           Notwithstanding the forgoing detailed description of preferred embodiments, it will be apparent that many alterations and modifications may be made by those having ordinary skill in the art without departing from the spirit and scope of the invention. Therefore, it must be understood that the illustrated embodiments have been set forth only for the purposes of examples and that they should not be taken as limiting the invention as defined  
10 by the following claims. For example, notwithstanding the fact that the elements of a claim are set forth below in a certain combination, it must be expressly understood that the invention includes other combinations of fewer, more or different elements.

Also, the words used in this specification to describe the invention and its various  
15 embodiments are to be understood not only in the sense of their commonly defined meanings, but to include by special definition in this specification the generic structure, material or acts of which they represent a single species.

The definitions of the words or elements of the following claims are, therefore, defined in this specification to not only include the combination of elements which are literally set forth. In this sense it is contemplated that an equivalent substitution of two or  
20 more elements may be made for any one of the elements in the claims below or that a single element may be substituted for two or more elements in a claim. Although elements may be described above as acting in certain combinations and even initially claimed as such, it is to be expressly understood that one or more elements from a claimed combination can in some cases be excised from the combination and that the claimed  
25 combination may be directed to a subcombination or variation of a subcombination.

Insubstantial changes from the claimed subject matter as viewed by a person with ordinary skill in the art, now known or later devised, are expressly contemplated as being

equivalently within the scope of the claims. Therefore, obvious substitutions now or later known to one with ordinary skill in the art are defined to be within the scope of the defined elements.

5 The claims are thus to be understood to include what is specifically illustrated and described above, what is conceptionally equivalent, what can be obviously substituted and also what incorporates the essential idea of the invention.